MEGA LECTURE

A LEVEL CHEMISTRY

TOPIC 12 – ACIDS, BASES AND BUFFERS

ASSESSED HOMEWORK

Answer all questions

Max 80 marks

Name ……
Mark ……../80 ……..% Grade ……

1.

2. A student was given a task to determine the percentage purity of a sample of salicylic acid. The method used by the student to prepare a solution of salicylic acid is described below.

- 0.500 g of an impure sample of salicylic acid was placed in a weighing bottle.
- The contents were tipped into a beaker and 100 cm^3 of distilled water were added.
- Salicylic acid does not dissolve well in cold water so the beaker and its contents were heated gently until all the solid had dissolved.
- The solution was poured into a 250 cm^3 graduated flask and made up to the mark with distilled water.

(a) Give **two** additional instructions that would improve this method for making up the salicylic acid solution.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(2)

(b) The pH of this solution was measured and a value of 2.50 was obtained.
Calculate the concentration of salicylic acid in this solution.
Assume that salicylic acid is the only acid in this solution. The K_a for salicylic acid is 1.07×10^{-3} mol dm^{-3}. You may represent salicylic acid as HA.
Show your working.

.....
.....

.....
.....

.....
.....

.....

.....

.....
.....

(3)

(c) Use your answer to part (b) to calculate the mass of salicylic acid (M_r = 138.0) present in the original sample.
(If you were unable to complete the calculation in part (b), assume that the concentration of salicylic acid is 8.50×10^{-3} mol dm^{-3}. This is **not** the correct answer.)

.....
.....

.....
.....

.....
.....

(2)

(d) Use your answer to part (c) to calculate the percentage purity of the salicylic acid used to make the solution.
(If you were unable to complete the calculation in part (c), assume that the mass of salicylic acid is 0.347 g. This is **not** the correct answer.)

.....
.....

.....
.....

(1)
(Total 8 marks)

2. In this question, give all values of pH to two decimal places.

Calculating the pH of aqueous solutions can involve the use of equilibrium constants such as K_w and K_a

K_w is the ionic product of water. The value of K_w is 5.48×10^{-14} mol^2 dm^{-6} at 50 °C.

(a) (i) Write an expression for pH.

.....
.....

(1)

(ii) Write an expression for K_w

.....
.....

(1)

(b) (i) Calculate the pH of pure water at 50 °C.

.....
.....

.....
.....

.....
.....

(2)

(ii) Suggest why this pure water is **not** acidic.

.....
.....

.....
.....

(1)

(iii) Calculate the pH of 0.140 mol dm^{-3} aqueous sodium hydroxide at 50 °C.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(3)

(c) Calculate the pH of the solution formed when 25.0 cm^3 of 0.150 mol dm^{-3} aqueous sulfuric acid
are added to 30.0 cm^3 of 0.200 mol dm^{-3} aqueous potassium hydroxide at 25 °C. Assume that the sulfuric acid is fully dissociated.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....

.....

.....

.....

.....

.....

(6)

(Total 14 marks)

3. This question is about several Brønsted–Lowry acids and bases.

(a) Define the term *Brønsted–Lowry* acid.

.....
.....

.....
.....

(1)

(b) Three equilibria are shown below. For each reaction, indicate whether the substance immediately **above** the box is acting as a Brønsted–Lowry acid (**A**) or a Brønsted–Lowry base (**B**) by writing **A** or **B** in each of the six boxes.

(i) CH_3COOH + H_2O ⇌ CH_3COO^- + H_3O^+

(1)

(ii) CH_3NH_2 + H_2O ⇌ $CH_3NH_3^+$ + OH^-

(1)

(iii) HNO_3 + H_2SO_4 ⇌ $H_2NO_3^+$ + HSO_4^-

(1)

(c) A 25.0 cm^3 sample of 0.0850 mol dm^{-3} hydrochloric acid was placed in a beaker.
Distilled water was added until the pH of the solution was 1.25.

Calculate the total volume of the solution formed. State the units.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(3)

(d) At 298 K, the value of the acid dissociation constant (K_a) for the weak acid HX in aqueous solution is 3.01×10^{-5} mol dm^{-3}.

(i) Calculate the value of pK_a for HX at this temperature.
Give your answer to 2 decimal places.

.....
.....

.....
.....

(1)

(ii) Write an expression for the acid dissociation constant (K_a) for the weak acid HX.

.....
.....

.....
.....

.....
.....

(1)

(iii) Calculate the pH of a 0.174 mol dm^{-3} solution of HX at this temperature.
Give your answer to 2 decimal places.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(3)

(e) An acidic buffer solution is formed when 10.0 cm^3 of 0.125 mol dm^{-3} aqueous sodium hydroxide are added to 15.0 cm^3 of 0.174 mol dm^{-3} aqueous HX.
The value of K_a for the weak acid HX is 3.01×10^{-5} mol dm^{-3}.

Calculate the pH of this buffer solution at 298 K.
Give your answer to 2 decimal places.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(6)
(Total 18 marks)

4. A 0.210 mol dm^{-3} solution of potassium hydroxide was added from a burette to 25.0 cm^3 of a 0.160 mol dm^{-3} solution of ethanoic acid in a conical flask. Given that the value of the acid dissociation constant, K_a, for ethanoic acid is 1.74×10^{-5} mol dm^{-3}, calculate the pH at 25 °C of the solution in the conical flask at the following three points:

before any potassium hydroxide had been added;

.....
.....

.....
.....

.....
.....

.....
.....

after 8.0 cm^3 of potassium hydroxide solution had been added;

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

after 40.0 cm^3 of potassium hydroxide solution had been added.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(Total 16 marks)

5. The acid dissociation constant, K_a, for ethanoic acid is given by the expression

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

The value of K_a for ethanoic acid is 1.74×10^{-5} mol dm^{-3} at 25 °C.

(a) A buffer solution is prepared using ethanoic acid and sodium ethanoate. In the buffer solution, the concentration of ethanoic acid is 0.186 mol dm^{-3} and the concentration of sodium ethanoate is 0.105 mol dm^{-3}.

Calculate the pH of this buffer solution.
Give your answer to 2 decimal places.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(3)

(b) In a different buffer solution, the concentration of ethanoic acid is 0.251 mol dm^{-3} and the concentration of sodium ethanoate is 0.140 mol dm^{-3}.

A sample of hydrochloric acid containing 0.015 mol of HCl is added to 1000 cm^3 of this buffer solution.

Calculate the pH of the buffer solution after the hydrochloric acid has been added.
You should ignore any change in total volume.
Give your answer to 2 decimal places.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

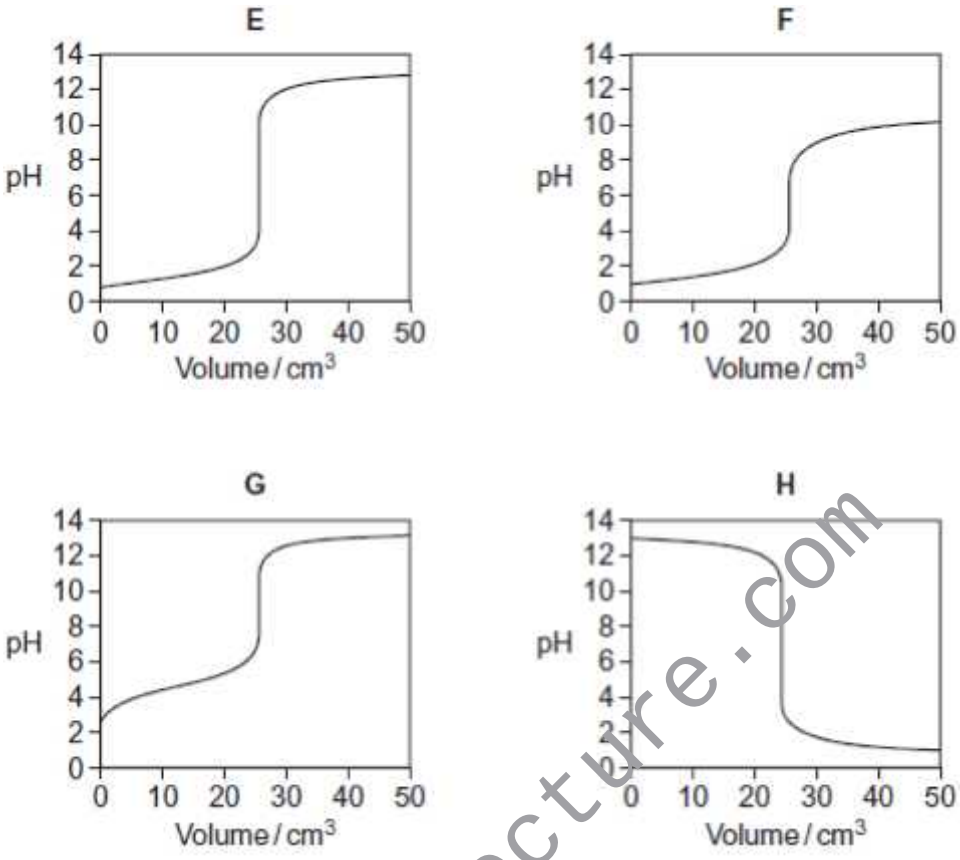
.....
.....

.....
.....

(5)
(Total 8 marks)

6. Titration curves, labelled **E**, **F**, **G** and **H**, for combinations of different aqueous solutions of acids and bases are shown below.

All solutions have concentrations of 0.1 mol dm^{-3}.



(a) In this part of the question, write the appropriate letter in each box.

From the curves **E**, **F**, **G** and **H**, choose the curve produced by the addition of

(i) sodium hydroxide to 25 cm^3 of ethanoic acid

(1)

(ii) ammonia to 25 cm^3 hydrobromic acid

(1)

(iii) hydrochloric acid to 25 cm^3 of potassium hydroxide

(1)

(b) The table shows information about some acid-base indicators.

Indicator	**pH range**	**Lower pH colour**	**Higher pH colour**
pentamethoxy red	1.2 – 3.2	violet	colourless
naphthyl red	3.7 – 5.0	red	yellow
4 nitrophenol	5.6 – 7.0	colourless	yellow
cresol purple	7.6 9.2	yellow	purple

(i) Which indicator in the table could be used for the titration that produces curve **E** but **not** for the titration that produces curve **F**?

Tick (✓) **one** box.

pentamethoxy red ☐

naphthyl red ☐

4 nitrophenol ☐

cresol purple ☐

(1)

(ii) Give the colour change at the end point of the titration that produces curve **H** when naphthyl red is used as the indicator.

.....
.....

(1)

(iii) A beaker contains 25 cm^3 of a buffer solution at pH = 6.0
Two drops of each of the four indicators in the table are added to this solution.

State the colour of the mixture of indicators in this buffer solution.

You should assume that the indicators do **not** react with each other.

.....
.....

(1)
(Total 6 marks)

7. When iron(II) sulfate is used for killing weeds in lawns, it is often mixed with the fertiliser ammonium sulfate. Ammonium sulfate also makes the soil acidic.

(a) Write an equation to show how the ammonium ion behaves as a Brønsted–Lowry acid in water.

.....
.....

(1)

(b) Compounds such as ammonium sulfate react on warming with sodium hydroxide solution as shown in the equation below.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$$

Use this information to describe a simple test, other than smell, to show that ammonia is evolved. State what you would observe.

Test .....
.....

.....
.....

Observation .....
.....

(2)
(Total 3 marks)

8. Describe briefly how you would ensure that a reading from a pH meter is accurate.

.....
.....

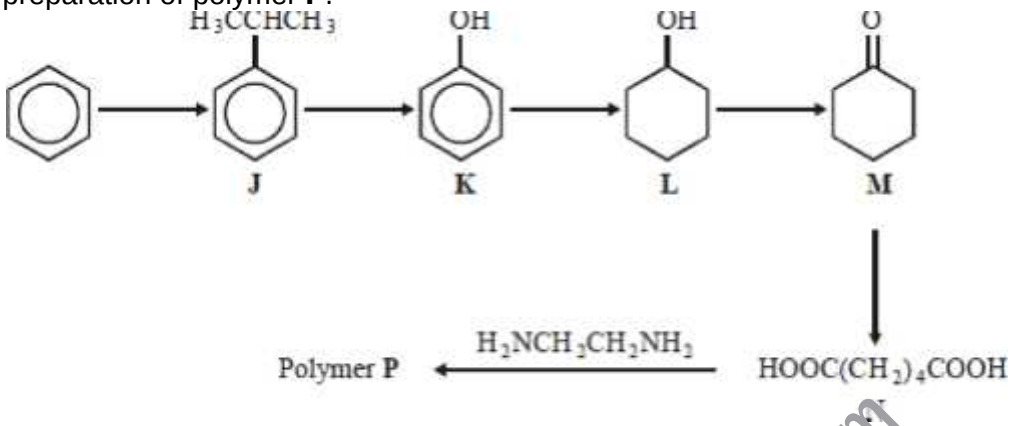
.....

.....

.....
.....

(Total 2 marks)

9. This question is about the following reaction scheme which shows the preparation of polymer **P**.



K is a weak acid with a pK_a of 9.95. The pH of a 0.10 mol dm^{-3} solution of **K** is

A 4.48

B 4.98

C 5.48

D 5.98

(Total 1 mark)

10. A solution of sodium ethanoate has a pH of 8.91 at 25 °C. The hydrogen ion and hydroxide ion concentrations in this solution are

A [H^+] = 1.00 × 10^{-9} mol dm^{-3} [OH^-] = 1.00 × 10^{-5} mol dm^{-3}

B [H^+] = 1.00 × 10^{-9} mol dm^{-3} [OH^-] = 8.13 × 10^{-6} mol dm^{-3}

C [H^+] = 1.23 × 10^{-9} mol dm^{-3} [OH^-] = 1.00 × 10^{-5} mol dm^{-3}

D [H^+] = 1.23 × 10^{-9} mol dm^{-3} [OH^-] = 8.13 × 10^{-6} mol dm^{-3}

(Total 1 mark)

11. Which one of the following is the change in units of pH which occurs when 10.0 cm^3 of a 1.0 M solution of a strong monoprotic acid are made up to 1.0 dm^3 with water?

A 1

B 2

C 3

D 5

(Total 1 mark)

12. Which one of the following could be true in an aqueous solution of sodium hydroxide?

A $[H^+] = [OH^-]$

B $pH = \log_{10} [OH^-]$

C pH = 1.2

D pH = 12.8

(Total 1 mark)

13. Use the information below to answer this question.

A saturated solution of magnesium hydroxide, $Mg(OH)_2$, contains 0.1166 g of $Mg(OH)_2$ in 10.00 dm^3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the pH of a solution of magnesium hydroxide containing 4.0×10^{-5} $mol\ dm^{-3}$ of hydroxide ions at 298 K?
($K_w = 1.0 \times 10^{-14}$ $mol^2\ dm^{-6}$ at 298 K)

A 9.6

B 9.5

C 8.6

D 8.3

(Total 1 mark)